

THREE NEW SPECIES OF *RENOCILA*
(CRUSTACEA: ISOPODA: CYMOTHOIDAE),
EXTERNAL PARASITES OF CORAL REEF FISHES
FROM THE RYUKYU ISLANDS OF JAPAN

Lucy Bunkley Williams and Ernest H. Williams, Jr.

Abstract. — *Renocila yamazatoi*, n. sp., is described from *Chromis ovaliformis* collected at Iriomote Island; *R. kohnoi*, n. sp., from *Centropyge heraldi* and *C. vrolicki* collected at Iriomote and Ishigaki islands; and *R. bollandi*, n. sp., from *Scorpaenopsis cirrhosa* and *Scorpaena bynoensis* collected at Okinawa Island. *Renocila yamazatoi* is distinguished by extremely long exopods of the uropods, lengthened dactyls of pereopods 2-6, and posteroventral angles of pereonite 7 extending to or beyond pleonite 3; *R. kohnoi* by swellings on the dactyls and lobes on posterodistal corners of basis of pereopods 1-3 and also swelling on dactyls of pereopod 4, antennae 1 longer than 2, and posteroventral angles of pereonite 7 extending to pleonite 5 or further; *R. bollandi* by pereonites and pleonites with medial posterior projections, produced posteroventral angles of pereonites 4-7, and an immersed head. Darkly colored *R. kohnoi* contrasts strikingly with the yellow body of *C. heraldi* but this isopod is camouflaged on *C. vrolicki*. The juveniles of *R. kohnoi* attach to the host soon after escaping from the brood pouch of the female. The duplex female-male arrangement could be a precursor to both the double female-micromale pattern and the traditional female-male pattern of cymothoids. *Renocila yamazatoi* and *R. kohnoi* occurred in the same geographic location, only *R. bowmani* and *R. colini* have so overlapped previously. The limited geographic ranges, high levels of infection, and strong host specificity previously suggested for members of *Renocila* apply to these new species.

Five species of *Renocila* have been described from the Indo-west Pacific (Bowman and Mariscal 1968). Williams and Williams (1980) described four additional species in this genus from the Caribbean and eastern Pacific and suggested a circum-tropical distribution for this genus. The present study describes three new species, the first from the subtropical western Pacific.

Materials and Methods

Fishes with isopods were collected with an elastic band speargun or quinaldine fish relaxant and nets, using scuba. Hosts were immediately sealed in individual plastic

bags, and held in a mesh diving bag for no more than two hours. Hosts were measured for standard and total length to the nearest millimeter and preserved in 10% formalin. Isopods were measured for total length (from anterior margin of head to posterior extent of uropods), head to pleotelson length (anterior margin of head to posterior margin of pleotelson), and maximum width to the nearest 0.1 mm, using slight pressure on the dorsal surface to straighten any curling, and preserved in 70% ethanol. Broods were removed from preserved female isopods, counted, and a random sample of 20 measured for total length and maximum width to the nearest 0.01 mm. Mouthparts and

appendages were mounted in glycerine jelly and drawn with the aid of a Nikon projection microscope. Whole specimens were drawn with a Nikon SMZ-10 stereo microscope with a built-in camera lucida. Photographs were taken with a Nikon F2 camera and 55 mm macro-lens. Pleotelsons of the illustrated specimens were drawn in a natural or slightly depressed position; therefore, the length of pleotelsons in illustrated dorsal views do not represent the actual total lengths. Measurements are given in mm, means in parentheses. Isopod specimens are deposited in the Division of Crustacea and fish hosts in the Division of Fishes of the National Museum of Natural History, Smithsonian Institution (USNM). Names of the hosts follow Masuda et al. (1984).

Renocila yamazatoi, new species

Figs. 1–31, 70–73, Table 1

Specimens examined.—14 specimens: 2 females, 3 males, 25 to 26 Nov 1985, south of Saba Saki (Point), Amitori Bay, Iriomote Island, Japan, 24°20.15'N, 123°41.80'E.—4 females, 3 males, 2 juveniles, 26 Nov 1985, off Toubari Saki (Point), Funauki Bay, Iriomote Island, Japan.

Type specimens.—Holotype (female), USNM 231049, allotype (associated male), USNM 231050; 12 paratypes, USNM 231051–231056.

Type locality.—Reef slope off Toubari Saki, Funauki Bay, Iriomote Island, Japan, 24°20.35'N, 123°43.30'E.

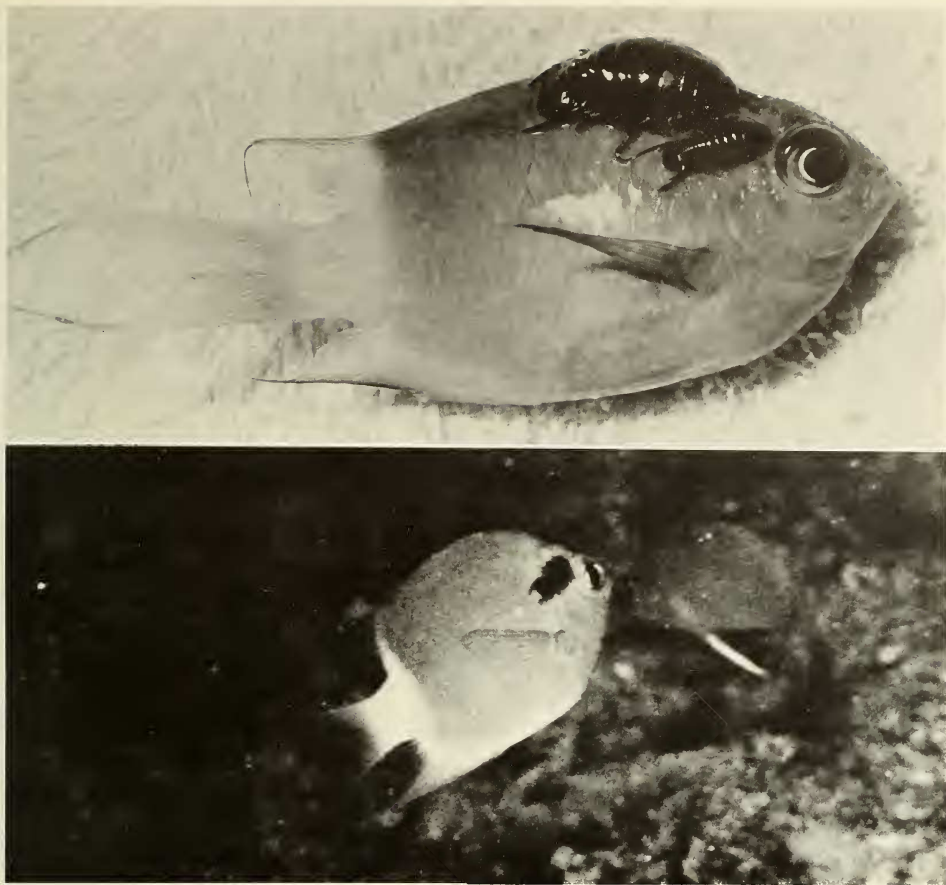
Type host.—Maru-suzumedai, *Chromis ovatififormis* Fowler (Perciformes: Pomacentridae) (Fig. 1), USNM 267533–267534.

Site of infection.—Male attaches on the side of the head above the posterior portion of the eye of the host. The female attaches directly above the male (Fig. 1).

Description.—Body elongate oval. Antennae 1 7–8-merous. Antennae 2 6-merous. Antennae 1 with setae present on distal ventral corners of distal 5 articles, broader and longer than antennae 2. Anterior mar-

gin of head broadly rounded, ventrally flexed, produced into lobe between bases of antennae 1. First segment of mandibular palp not expanded, 4 simple setae on inner margin of distal segment. Incisor process of mandible with pointed tip and expanded proximal portion. Maxilla 1 with 1 large and 3 smaller recurved apical spines. Distal lobes of maxilla 2 each with 2 short blunt spines; distal portion of semilunar pectinate scales longer than those on other mouthparts. Distal segment of maxillipedal palp with 3 stout recurved spines. Posteroventral angles of pereonite 4 moderately produced, 5–7 produced, that of pereonite 7 extending posteriorly to level of pleonite 3 to pleotelson. Median ridge on pleon, low anteriorly, becoming more raised posteriorly. Pleonite 5 with medial posterior projection. Pleotelson heart-shaped, 1.36–1.76 times wider than long. Uropod extending far beyond posterior margin of pleotelson, exopod twice or more than twice as long as endopod. Pereopods 1–3 without swelling in dactyl and without lobe at posterodistal corner of basis. Dactyls of pereopods increasing in length from 1 to 4 and decreasing in length from 4 to 7. Dactyls of pereopods 2–6 very long and slender, those of pereopods 1 and 7 abruptly shorter than other dactyls. Pereopods all subequal in length. Color of body and appendages uniformly slate gray.

Juvenile (attached to host) (n = 2): Total length 3.0 and 3.7, head to pleotelson length 2.6 and 3.1, maximum width 1.1 and 1.3. Appendix masculina of pleopod 2 as long as endopod. Penes lobes absent. No comb-like teeth on inner margin of dactyls or hooks on inner margin of propodus of pereopods 1–3. Body uniformly slate gray except lateral margins of pereon and pleon and exopod of uropods which slightly darker. This coloration differs from juvenile or manca larvae of brood pouch, which have lateral row of dark pigment spots in band along outer margins of pereon, pleon, and exopod of uropod; pigment spots on posterior margins of pereonites, pleonites, and anterior



Figs. 1, 2. 1, (top): Female (19.1 mm) and male (11.5 mm) *Renocila yamazatoi* on 51 mm SL maru-suzumedai, *Chromis ovatiformis* Fowler, laboratory photograph at Amitori; 2, (bottom): Male *Renocila yamazatoi* on the maru-suzumedai, *Chromis ovatiformis* Fowler, underwater photograph by senior author, 15 m depth, south of Saba Saki, 25 Nov 1985, first specimen observed, not collected.

margin of head; diffuse small pigment spots over dorsal surface of body; some pigment spots outlining parts of pereopods, pleopods and labrum.

Male (n = 6): Total length 5.7–11.6 (8.0), head to pleotelson length 5.0–9.5 (6.8), maximum width 2.1–5.0 (3.4). Penes lobes of male separate. Appendix masculina of pleopod 2 linear with unmodified apex. Color uniformly slate gray.

Female (n = 6): Total length 11.9–19.1 (14.6), head to pleotelson length 11.3–17.8 (13.7), maximum width 6.0–9.5 (7.7). No remnants of appendix masculina or penes

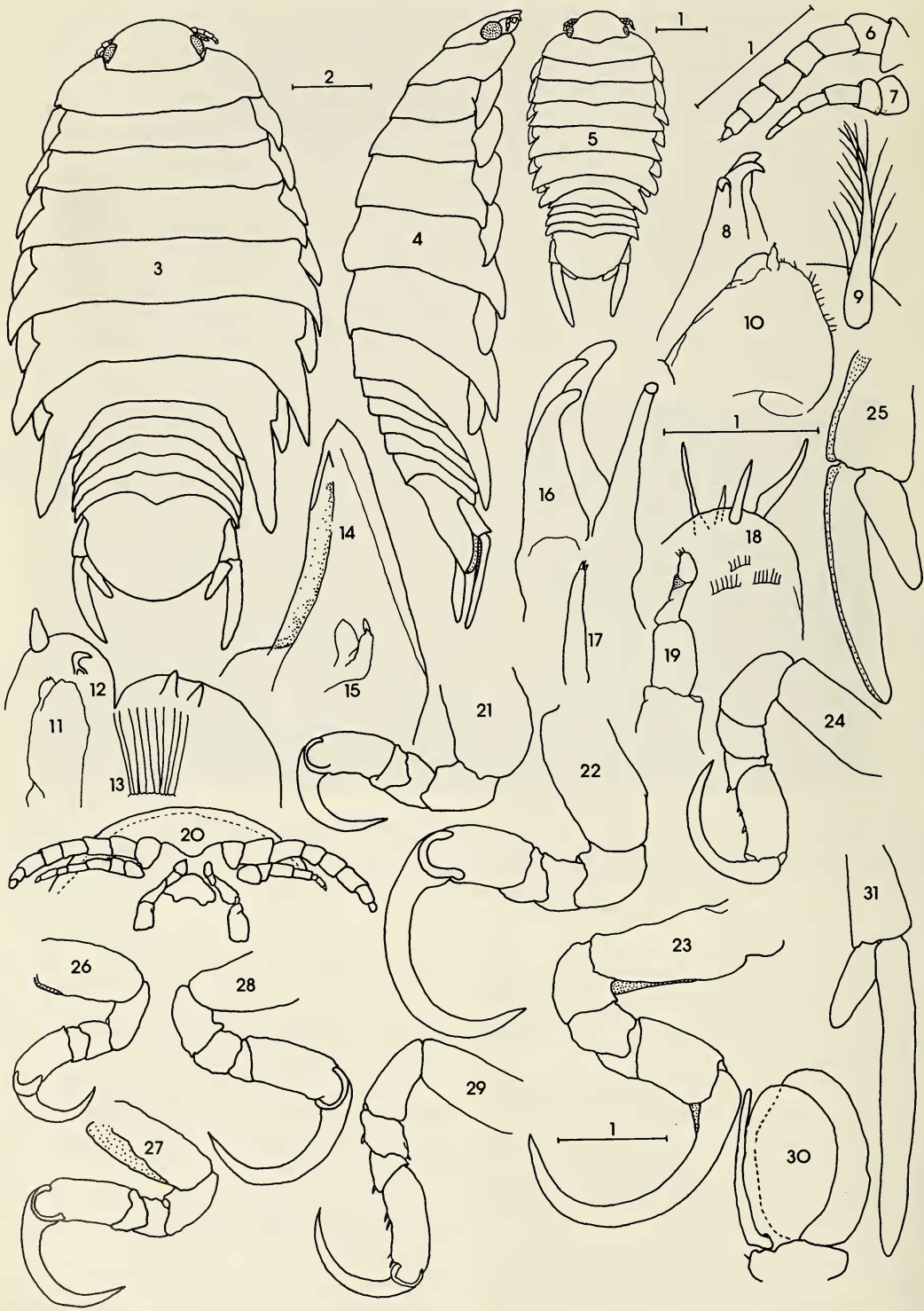
lobes present. All but one female (13.2 × 7.7) possess oostegites.

Brood pouch reproduction (n = 20 of each brood). (See Table 1.)

Etymology. — The specific name is in honor of Dr. Kiyoshi Yamazato, who made our visit to, and research throughout Japan possible.

Japanese standard common name: Yamazato-yadori-mushi (shin-shô) = Yamazato's isopod.

Remarks. — *Renocila yamazatoi* most closely resembles *R. heterozota* Bowman and Mariscal by having an exopod of the uropod



Figs. 3-31. *Renocila yamazatoi*, new species (3, 4, 20 = 15.4 mm female holotype with oostegites; 5 = 7.0 mm male allotype; 6-19, 21-25 = 15.3 mm female paratype with oostegites; 26-31 = 11.6 mm male paratype)

Table 1.—Description of development in the brood pouch of 4 females of *Renocila yamazatoi* (measurements in mm).

Number	Description	Length (mean)	Width (mean)
229	Subspherical embryos	0.75–0.86 (0.79)	0.65–0.75 (0.70)
16 ¹	Hunched embryos with internal segmentation, broad cephalic end and darkly pigmented eyes	1.25–1.41 (1.31)	0.62–0.76 (0.67)
348 ¹ , 1 ²	Manca larvae with eyes, antennae and 6 pereopods, no pigment spots, body compressed	2.15–2.45 (2.26)	0.65–0.75 (0.70)
148 ² , 121	Juveniles with flattened pigmented body (as described in text)	2.16–2.36 (2.28)	0.66–0.75 (0.72)

¹ Mixed brood, 16 and 348 in same female.
² Mixed brood, 1 and 148 in same female.

twice as long as the endopod, anterior margin of head inflexed and produced into rounded lobe between bases of antennae 1, pereopods 1–3 without swelling of the dactyls and without lobate posterodistal corners of the basis. It differs from *R. heterozota* and all other known *Renocila* species by the lengthened dactyls of pereopods 2–6. It also differs from *R. heterozota* by having the posteroventral angles of pereonite 5 produced and those of pereonite 7 extending laterally to or beyond pleonite 3.

The 14 *R. yamazatoi* were attached to seven *Chromis ovatifformis* 35–52 (46.6) in standard length. Masuda et al. (1984) noted that few reports of *Chromis ovatifformis* had been published since its description in 1946 because of its deep habitat, between 20 and 40 m, seldom swimming shallower. In the present study, *C. ovatifformis* with *R. yamazatoi* were observed as shallow as 6.1 m and isopods were collected on fish at 7.6 m to 18 m depth. Those observed at 6.1 m were associated with vertical rock faces. Unparasitized fish were abundant as shallow as 9 m in dead, intact, branched *Ac-*

ropora sp. (Scleractinia: Acroporidae) on reef slopes that reached into deep water (80 m). This fish was abundant in similar depths off Ishigaki, Kuro, and Okinawa islands, but was not observed parasitized by *R. yamazatoi*. *Chromis ovatifformis* were infected with one or more *R. yamazatoi* in 8.3–15.0% (12.3%) of those observed (three observation periods for a total of 130 fish).

Five *C. ovatifformis* were collected with isopods in male-female pairs (Fig. 1); 1 with a female-juvenile pair; and 1 was host to a single large male. One juvenile was associated with a male-female pair.

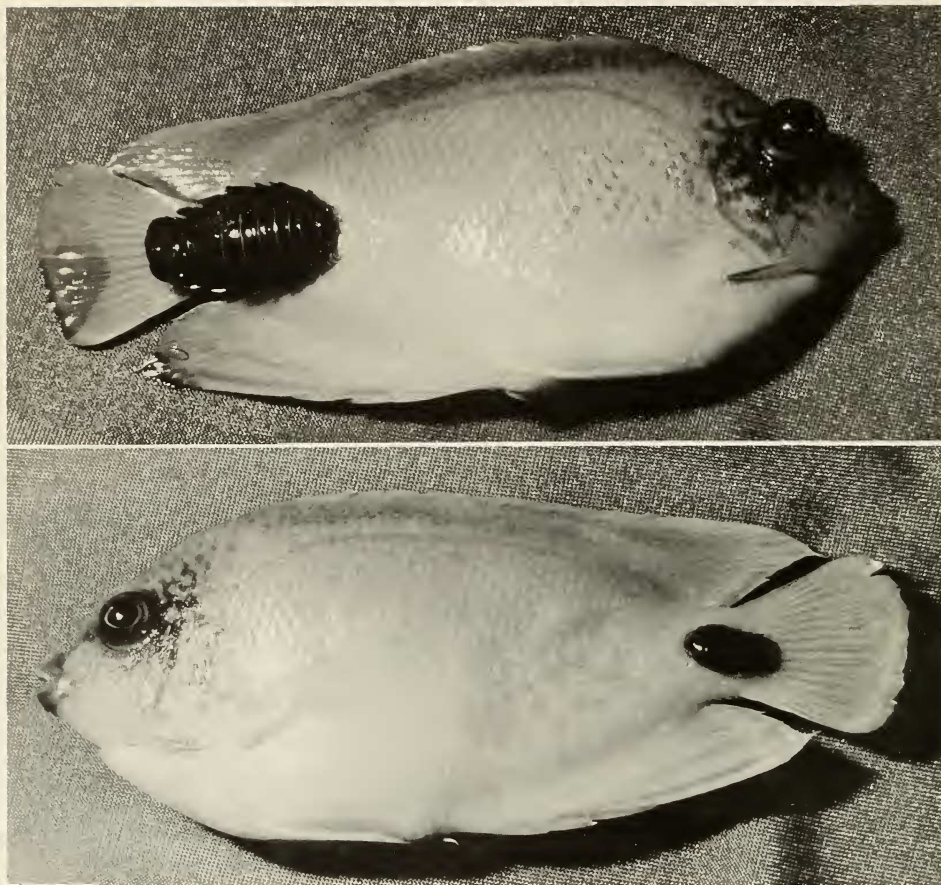
Two lengths are given for *R. yamazatoi* because the uropods reach far beyond the posterior border of the pleotelson. Total length is not representative of the body length of this isopod.

Renocila kohnoi, new species
Figs. 32–59, 74–77, Tables 2–3

Specimens examined.—Thirty specimens: 5 females, 3 male-female transitionals, 3 males, 1 juvenile-male transitional, 2

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(Scale bars in mm; scale of 3 and 4 equal; scale of 6, 7, 10, 11, 15, 17, 19 equal; scale of 20–31 equal; 8, 9, 12–14, 16, 18 enlargements from associated mouthpart figures). 3, Dorsal view; 4, Lateral view; 5, Dorsal view; 6, Antennae 1; 7, Antennae 2; 8, Apex of maxillipedal palp; 9, Seta of maxilliped; 10, Maxilliped; 11, Maxilla 2; 12, Distal lobes of maxilla 2; 13, Semilunar pectinate scale on maxilla 2; 14, Incisor process of mandible; 15, Mandible; 16, Apex of maxilla 1; 17, Maxilla 1; 18, Apex of distal segment of mandibular palp, with scales; 19, Mandibular palp; 20, Head, ventral view; 21, Pereopod 1; 22, Pereopod 2; 23, Pereopod 4; 24, Pereopod 7; 25, Uropod; 26, Pereopod 1; 27, Pereopod 2; 28, Pereopod 4; 29, Pereopod 7; 30, Pleopod 2; 31, Uropod.



Figs. 32, 33. 32, (top): Female (21.2 mm) *Renocila kohnoi* on 78 mm SL herarudo-koganeyakko, *Centropyge heraldi* Woods and Schultz, laboratory photograph at Amitori; 33, (bottom): Male (11.3 mm) on side opposite female in Fig. 32 (note old wound of a female isopod anterior and overlapping position of "new" male).

juveniles, 27 Nov 1985, reef front in mouth of Sakiyama Bay, Iriomote Island, Japan, 24°18.97'N, 123°40.35'E; 4 females, 8 males, 1 juvenile-male transitional, 3 juveniles, 4 Dec 1985, Fukapi "Atoll" (local name), Yonehara Reef, NE of Tomino, Ishigaki Island, Japan.

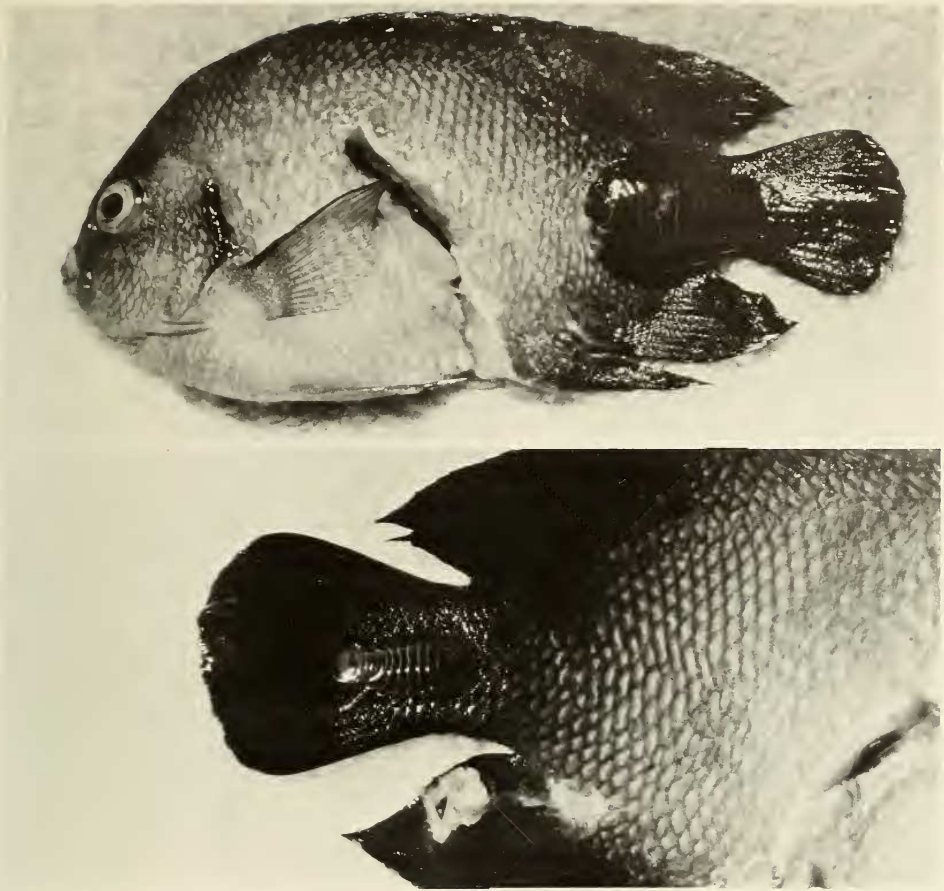
Type specimens. — Holotype (female), USNM 231057, allotype (associated male), USNM 231058, 28 paratypes, USNM 231059–231068.

Type locality. — South side, Fukapi "Atoll" (local name), Yonehara Reef, NE of Tomino, Ishigaki Island, Japan, 24°27.7'N, 124°10.61'E.

Type host. — Herarudo-koganeyakko, *Centropyge heraldi* Woods and Schultz (Perciformes: Pomacentridae) (Figs. 32–33), USNM 276531.

Additional host. — Namerayakko, *Centropyge vrolicki* (Bleeker) (Figs. 34–35), USNM 276532.

Site of infection. — Female attaches along center of the lateral side of the host just anterior of the caudal peduncle. The male attaches on the opposite side of the fish on the caudal peduncle (Figs. 32–35). Additional males attached anterior of the female or on the posterior tips of the dorsal and anal fins in some hosts. Juveniles attached

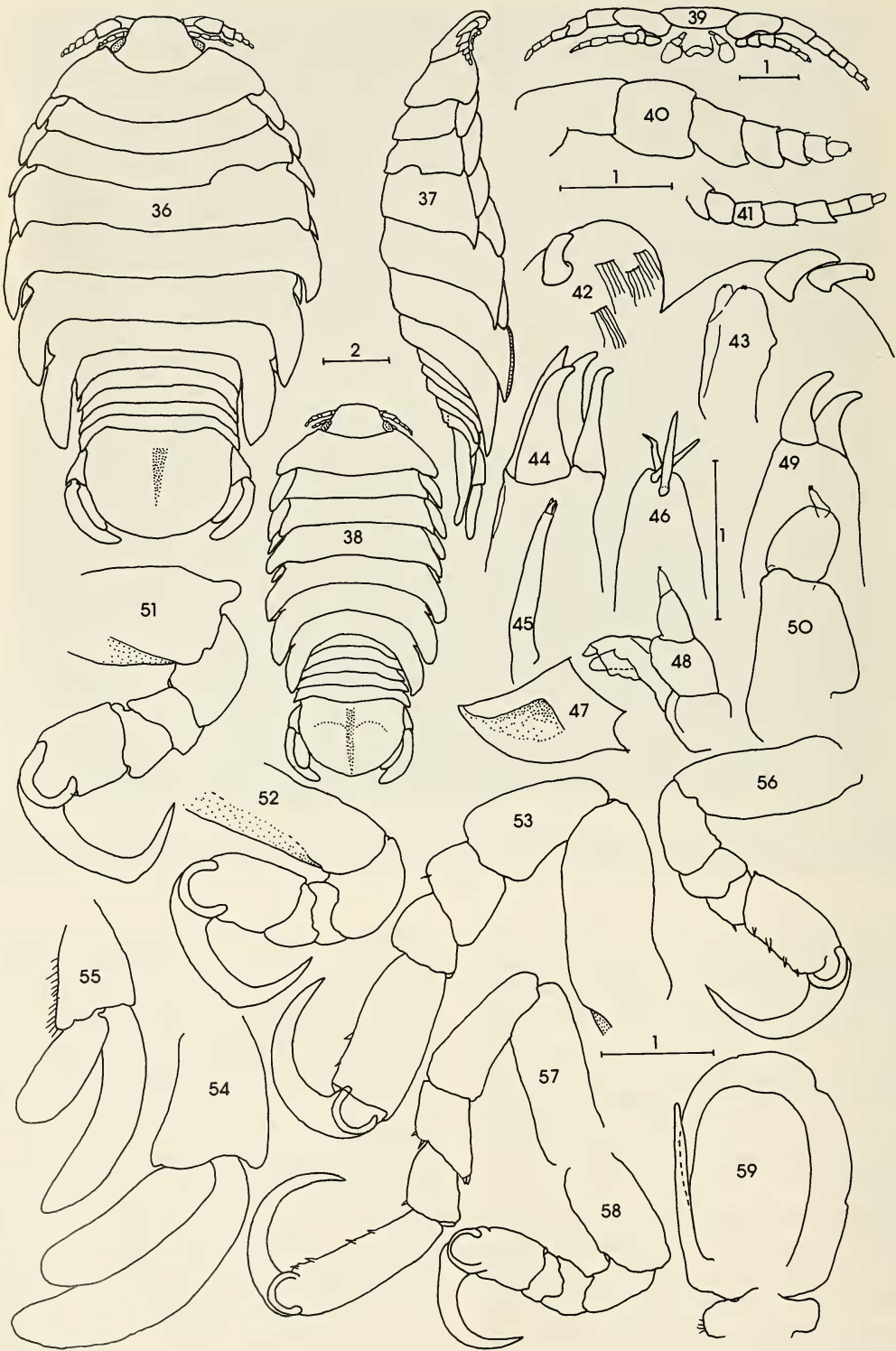


Figs. 34, 35. 34, (top): Female (20.7 mm) *Renocila kohnoi* on 73 mm SL namerayakko, *Centropyge vrolicki* (Bleeker), laboratory photograph an Amitori; 35, (bottom): Male (9.6 mm) on side opposite female in Fig. 34.

on the posterior tips of the dorsal and anal fins in some hosts. On one host, three males were arranged in a tight triangle about mid-body along the center of the lateral side, anterior of the female. Two females were attached slightly posterior to the body mid-line, and one male was attached posterior of the caudal peduncle. Number of isopods per host varied from two to seven and averaged 2.9.

Description.—Body ovate. Antennae 1 7-merous, antennae 2 7–8-merous. Antennae 1 distinctly longer and wider than antennae 2, distal 5 articles with tufts of setae on distal ventral corners. Anterior margin of head ventrally flexed, produced into

broadened lobe between bases of antennae 1. First segment of mandibular palp slightly expanded, 3 simple setae on tip of distal article. Incisor process of mandible with pointed tip. Maxilla 1 with 1 slender and 3 more robust, recurved spines. Distal lobes of maxilla 2 with 1 spine on inner lobe and 2 spines on outer lobe, spines short and almost obscured by long distal portions of semilunar pectinate scales which are longer on this appendage than on others. Distal segment of maxillipedal palp with 2 recurved spines. Posteroventral angles of pereonite 1 moderately produced, those of 4–7 produced, and that of 7 extending to lateral portion of pleonite 5 or to posterior



extent of basis of uropods. Pleotelson semicircular, 1.43–1.75 (1.56) times wider than long with median ridge rising from posterior to anterior. Exopod of uropods only $\frac{1}{4}$ to $\frac{1}{2}$ longer than endopod. Exopod and not endopod reaching beyond posterior border of pleotelson but in 2 cases neither ramus attaining posterior border of pleotelson. Pereopods 1–4 with swelling of dactyls. Pereopods 1–3 with lobe at posterodistal corner of basis. Dactyls subequal in length, none lengthened. Pereopods 1–6 subequal in length or increasing in length slightly from 1–6. Pereopod 7 abruptly longer than pereopod 6. Color uniform slate gray.

Juvenile (attached to host) (n = 5): Total length 3.7–4.0 (3.9), maximum width 1.0–1.2 (1.1). Possessing 6 pairs of pereopods, no appendix masculina and no penes lobes. Three juveniles possessing setae on pleotelson and terminal portions of uropods; pereopods 1–3 with comb-like teeth on inner margin of dactyls and row of large hooks on inner margin of propodus; large chromatophores on snout along line between anterior extreme of eyes; large darkly pigmented lateral stripe from eyes along pereon, becoming more diffuse on sides of pleon, reappearing as dark stripe on outer edge of exopod of uropods; pigment spots outlining edges of pleopods 1 and 2, spots on distal outer margins of pleopod 3 and sometimes 4; pigment spots on midventral surface of pereopods; pigment spots dispersed along posterior borders and middle of pereonites and pleonites, forming elongated oval of pigment spots along mid-line of isopod. These 3 juveniles similar in size and mor-

phology to juveniles found in brood pouches of 2 female *R. kohnoi*. Remaining 2 attached juveniles (3.7 and 4.0 long, 1.1 and 1.2 wide) resembling first 3 except for pigment spots uniformly dispersed over dorsal surface; comb-like teeth on inner margins of dactyls and hooks present on inner margin of propodus of pleopods 1–3 reduced in length. This second morphological type may represent first molt after settling on host. These 5 juveniles all attached to fishes also parasitized by female *R. kohnoi* with reproductive products other than juveniles.

Juvenile-male transitional (n = 2): Total length 5.6 and 7.8, width 2.2 and 2.0. Both isopods possessing 7 pairs of pereopods, appendix masculina as long as or longer than endopod or pleopod 2, and no penes lobes apparent. Shorter (and wider) isopod colored uniformly slate gray (male coloration) and possessing no comb-like teeth on inner margins of dactyls or hooks on inner margins of propodus of any pereopods. Longer isopod similar in color and pereopod morphology to group of 2 attached juveniles described above.

Male (n = 11): Total length 5.6–11.3 (8.6), width 2.0–6.0 (4.1), appendix masculina linear with unmodified tip, slightly shorter to slightly longer than endopod of pleopod 2. Penes lobes small, bilobed, conical process. Possessing no remnants of comb-like teeth on inner margins of dactyls or hooks on inner margins of propodus. Color uniformly slate gray.

Male-female transitionals (n = 3): Total length 9.2–13.0 (10.5), width 4.4–7.0 (5.4) with appendix masculina shorter than inner

Figs. 36–59. *Renocila kohnoi*, new species (36, 37, 39 = 15 mm female holotype with oostegites; 38 = 11.1 mm male allotype; 40–54 = 18.6 mm female paratype lacking oostegites; 55–59 = 11.3 mm male paratype; all from *Centropyge heraldi*) scale bars in mm; scale of 36–38 equal; 40–41, and 51–59 equal; 43, 45, 48, and 50 equal; 42, 44, 46, 47, 49 enlargements from associated mouthpart figures). 36, Dorsal view; 37, Lateral view; 38, Dorsal view; 39, Head, ventral view; 40, Antennae 1; 41, Antennae 2; 42, Distal lobes of maxilla 2 with semilunar pectinate scales; 43, Maxilla 2; 44, Apex of maxilla 1; 45, Maxilla 1; 46, Apex of distal segment of mandibular palp; 47, Incisor process of mandible; 48, Mandible and palp; 49, Apex of maxillipedal palp; 50, Maxilliped; 51, Pereopod 1; 52, Pereopod 4; 53, Pereopod 7; 54, Uropod; 55, Uropod; 56, Pereopod 6; 57, Pereopod 7; 58, Pereopod 1; 59, Pleopod 2.

Table 2.—Description of development in the brood pouch of 4 females of *Renocila kohnoi* (measurements in mm).

Number	Description	Length (mean)	Width (mean)
111	Subspherical embryos	1.32–1.56 (1.44)	1.20–1.26 (1.22)
219	Hunched embryos with internal segmentation, broad cephalic end and darkly pigmented eyes	1.80–1.98 (1.86)	0.95–1.10 (1.04)
109, 109	Juveniles with racing stripes (as described in text)	3.95–4.11 (4.03)	1.09–1.15 (1.12)

blade of pleopod 2 and penes lobes not apparent. Color uniformly slate gray.

Female (n = 9): Total length 15.6–21.2 (18.8), width 9.7–13.2 (11.6), no remnants of appendix masculina or penes lobes present. All but 2 females (17.1 and 18.6 long and 11.2 and 11.3 wide), possessing oostegites.

Brood pouch reproduction (n = 20 of each): See Table 2.

Etymology.—The specific name is in honor of Mr. Hiroyoshi Kohno, who told us about this isopod, and helped us to collect specimens.

Japanese standard common name.—Kohno-yadori-mushi (shin-shô) = Kohno's isopod.

Remarks.—*Renocila kohnoi* resembles *R. periophthalmi* in general body shape. It differs from all known species of the genus by having swelling of the dactyl of pereopod 4 in addition to those on pereopods 1–3.

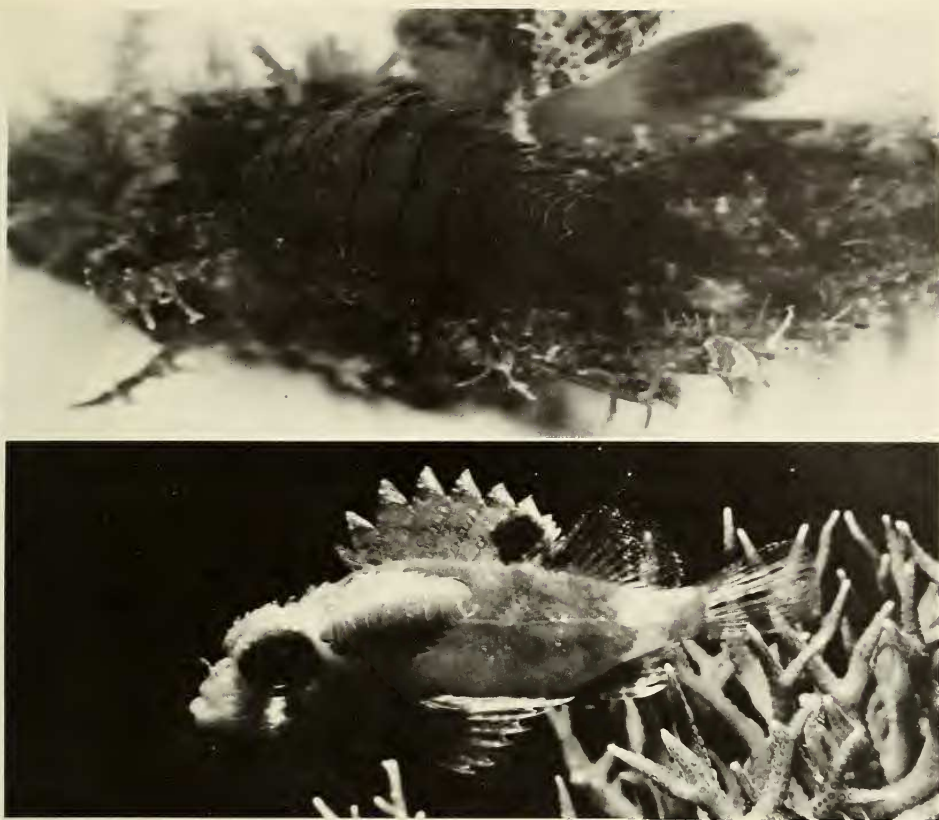
The 30 *Renocila kohnoi* were collected from eight *Centropyge heraldi*, 55–80 (68.1) in standard length, and two *C. vrolicki*, 69 and 73 in standard length. Parasitized *C. heraldi* were observed as deep as 27.4 m (collected at 24.3 m at Iriomote Island) and collected as shallow as 9.1 m at Ishigaki Island. Parasitized *C. vrolicki* were collected at 7.6 m at Iriomote Island and 6.1 m at Ishigaki Island and observed as shallow as 4.6 m at Ishigaki Island. Of the nine species of *Centropyge* reported from the Yaeyama Islands (Masuda et al. 1984), we observed seven. *Centropyge bispinosus* (Gunther), *C. tibicen* (Cuvier), *C. bicolor* (Bloch), *C. nox* (Bleeker), and *C. ferrugatus* Randall and Burgess were not observed to be parasitized

by external isopods. Twenty–thirty–three percent (22%) (five observations for a total of 98 fish) of *C. heraldi* and 20–40% (33.3%) (two observations for a total of 15 fish) of *C. vrolicki* were observed parasitized by *R. kohnoi*. Only one *C. heraldi* was observed with a single (male?) isopod (not collected); all other infections observed were by more than one isopod.

Renocila kohnoi, a dark-colored isopod, was very visible in the water attached to the yellow *C. heraldi* (Figs. 32–33). A similar situation exists with *Anilocra holacanthi* Williams and Williams, where the dark-colored isopod attaches under the eye of *Holacanthus tricolor* (Bloch) whose face is yellow (Williams and Williams 1981). *Renocila kohnoi* is almost invisible on *C. vrolicki* which is light brown on the anterior body and dark brown on the posterior one-third of the body and caudal peduncle where the isopod attaches (Figs. 34–35). The correspondence of the dark isopod to the limited dark areas of this host may be more than coincidence. Possibly *R. kohnoi* was first a parasite of *C. vrolicki* and later parasitized both hosts.

Four *R. kohnoi* were partially molted with the posterior three pereonites and the pleon in a softened condition, the head and pereonites 1–4 not molted.

Three of the five juveniles of *R. kohnoi* attached to the hosts were identical in size, shape, and coloration to the juveniles of the brood pouch (Table 2). These juveniles apparently attached to the host soon after leaving the brood pouch, and, therefore, may not have any intermediate planktonic period or intermediate host.



Figs. 60, 61. 60, (top): Female 13.9 mm holotype (USNM 228659) of *Renocila bollandi* on the 44 mm type-host specimen of onikasago, *Scorpaenopsis cirrhosa* (Thunberg), aquarium photograph by Dr. Robert F. Bolland; 61, (bottom): Female (uncollected) of *Renocila bollandi* on madara-fusakasago, *Scorpaena bynoensis* Richardson, from Onna Point, Okinawa, underwater photograph by Mr. Gary Hagland.

Renocila bollandi, new species

Figs. 60–69

Type specimen. — Holotype (female), USNM 228659.

Type locality. — “Horseshoe Cliffs,” 1 km WNW Onna Village, Okinawa, Japan, 26°30.0'N, 127°50.9'E (2 Jan 1985, 38.1 m, 0800 hrs, temperature at depth 24.8°C).

Type host. — Onikasago, *Scorpaenopsis cirrhosa* (Thunberg), Scorpaeniformes: Scorpaenidae) (Fig. 60).

Additional host and locality. — Madara-fusakasago, *Scorpaena bynoensis* Richardson (Fig. 61), Onna Point, Okinawa, Japan (20 Sep 1985, 12.2 m, 2200 hrs) (2 underwater photographs).

Site of infection. — Female attaches on the

anterior, lateral portion of the host, posterior of and dorsal of the eye (Figs. 60–61).

Description. — Body oval. Head immersed in pereonite 1. Eyes small. Antennae 1 6-merous, not reaching posterior border of head; antennae 2 3-merous, very short, reaching to third or fourth article of antennae 1. Anterior margin of head rounded, not ventrally flexed. Coxae of pereonites produced laterally, those of pereonites 2–3 reaching posterior extent of segments. Posterolateral angles of pereonite 3 moderately produced, those of pereonites 4–7 produced posteriorly and laterally, that of pereonite 7 extending posteriorly to level of lateral portion of pleonite 4–5. Pereonites and pleonites with projection at middle of posterior

border of segment, that of pleonite 5 larger than others, raised dorsally and extending over pleotelson. Medial ridge rises from anterior pereon to posterior pleon. In dorsal view, pleotelson deeply incised anteriorly by medial posterior projection of pleonite 5. Pleotelson 1.36 times wider than long, rounded posteriorly, slightly pointed at medial posterior border. Uropods extending to posterior border of pleotelson, exopod longer than endopod. Pereopods 1–3 without swelling of dactyls or lobate posterodistal corners of propodus. Dactyls and pereopods increasing in length from 1 to 3 or 4 (which are sub-equal) then decreasing gradually in length to pereopod 7. Pereopod 1 abruptly shorter than pereopod 2. Color, yellowish-brown with posterior borders of all segments and anterior border of head and pereonite 1 outlined by darkly pigmented line.

Female ($n = 1$): Total length 13.9, maximum width 8.8. No remnants of appendix masculina or penes lobes, with oostegites.

Etymology.—The specific name is in honor of Dr. Robert F. Bolland who collected, photographed, and provided additional information about this isopod.

Japanese standard common name.—Zebra-yadori-mushi (shin-shô) = zebra isopod.

Remarks.—Antennae, mouthparts, and uropods were not detached from the holotype to avoid damaging the single specimen.

Renocila bollandi differs from the diagnosis of the genus (Bowman and Mariscal 1968) by having an immersed head, produced posteroventral angle of pereonite 4, medial posterior projections of pereonites and pleonites, and reduced antennae 2.

The specimen of *Scorpaenopsis cirrhosa* was 44 in standard length and the observed and photographed *Scorpaena bynoensis* approximately 49 in standard length. Both hosts are young specimens. This isopod has been observed in depths from 12.2 to 38.1 m.

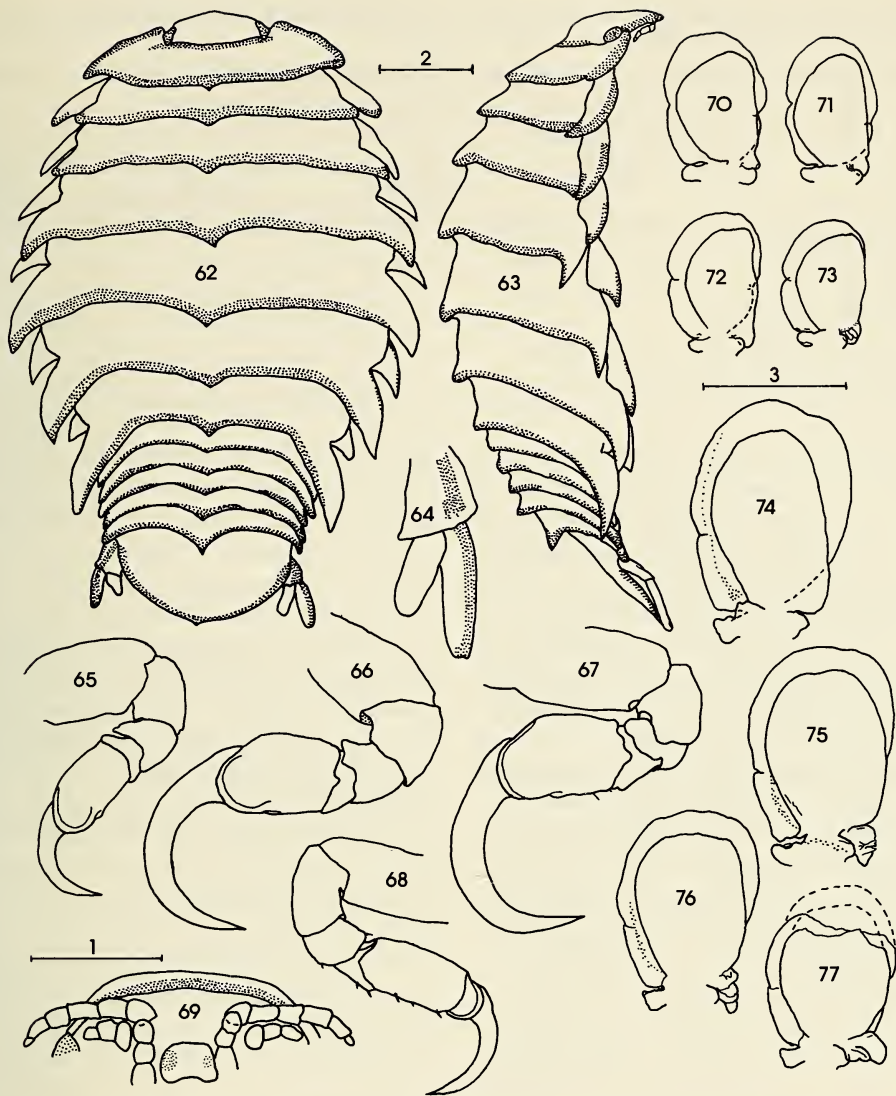
This isopod is known from a 500 m section of the west coast of central Okinawa.

We did not see this isopod during approximately 80 hrs of day and night scuba observations around Sesoko Island, 14–20 km north of Onna Point (May 1985–Mar 1986). We only observed one other common species of scorpaenid, satsumakasago, *Scorpaenopsis diabolus* (Cuvier), in the Ryukyu Islands, but it was never observed parasitized by this isopod.

Discussion

Cymothoids are traditionally associated in intimate, stable, long-term, female-male pairs. This process seems to be stabilized by neuro-endocrine control of the male by the female (as summarized by Brusca 1981). The female (or male) somehow excludes the attachment and growth of additional conspecific isopods. The constancy of this traditional pattern among almost all of the cymothoid isopods is probably based on the parasite-carrying capacity of hosts. No more than one female isopod and one male can be accommodated without threatening the survival of the host. The female isopod, through a series of non-growth reproductive cycles interspersed with vegetative growth periods (Williams and Williams 1982), probably grows to an optimum size for the size of the host. This is supported by the direct relationship between host length and female isopod length found in many cymothoids (Trilles 1964; Williams and Williams 1982). The obvious advantage of maximum female isopod size (as large as can be supported by the host) is that larger isopods (of the same species) produce more individual offspring. The number of eggs varies directly with body length within a species (Brusca 1981).

We have observed two major modifications of this traditional pattern. The first occurs in Caribbean *Anilocra*. The juvenile serves as a mobile male (micromale) and the host-carrying capacity, normally occupied by the male, can be taken by a second female. Thus the reproductive potential is



Figs. 62–69. *Renocila bollandi*, new species, 13.9 mm female holotype. (Scale bars in mm; scale of 62–63 equal, scale of 64–69 equal.) 62, Dorsal view; 63, Lateral view; 64, Uropods; 65, Pereopod 1; 66, Pereopod 2; 67, Pereopod 4; 68, Pereopod 7; 69, Head, ventral view.

Figs. 70–73. *Renocila yamazatoi*, new species, 15.3 mm female paratype. (Scale bars in mm; scale of 70–77 equal.) 70, Pleopod 2; 71, Pleopod 3; 72, Pleopod 4; 73, Pleopod 5.

Figs. 74–77. *Renocila kohnoi*, new species, 18.6 mm female paratype. 74, Pleopod 2; 75, Pleopod 3; 76, Pleopod 4; 77, Pleopod 5.

essentially doubled (Williams 1984). The second modification involves a physical separation of the female-male pair on the host. This duplex arrangement was described for *Mothocya bohlkeorum*, where a single male and female occupy different gill

chambers on a single host (Williams and Williams 1982). *Lironeca circularis* Pillai and *Lironeca* sp. also follow this pattern in 33 hosts (*Amblygaster sirm* (Walbaum)) we examined from Thailand and the Ryukyu Islands.

Table 3.—A developmental listing of 31 *Renocila kohnoi* arranged by hosts, and ranked in female-male pattern categories.

Status	Host number									
	1	2	3	4	5	6	7	8	9	10
	Developing toward duplex female-male			Stable duplex female-male		Developing toward traditional female-male			Developing toward female pair	
Development stage										
Female		1	1	1	1	1	1	1	1	1
Male-female transitional	1								1	1
Male			1	1	1	2	3	4		
Juvenile-male transitional	1	1								
Juvenile		1			2			2		

All species of the genus *Renocila* for which the attachment positions are known, except *R. kohnoi*, display the traditional female-male arrangement on the host. In contrast, *R. kohnoi* is strongly duplex in its female-male pattern by having the largest two isopods in the same position on opposite sides of the host. In addition, a number of smaller isopods also attach to the host and complicate this duplex pattern in five of the ten hosts examined. This combination of duplex arrangement and additional small isopods may indicate that this isopod-host relationship is a fairly recent phenomenon. By examining the specific relationships of these isopods on each host, we may gain some understanding of how the three basic arrangements came about.

Table 3 ranks the isopods occurring on each host by development stage, and also divides the assortment found on each host in terms of the three female-male patterns (Traditional female-male, Duplex female-male, and Double female-micromale). Our interpretation is that isopods on hosts 1 and 2 (Table 3) are developing toward a stable duplex female-male arrangement. The male-female transitional in host 1 will become a female and the juvenile-male transitionals in hosts 1 and 2 will become males. The isopods on hosts 3–5 are stable duplex female-male pairs. The attachment of the juveniles in host 5 is interesting because they could develop into males as in hosts 6–8,

but our field and aquarium experiments (Williams 1984) have demonstrated that mere attachment of juveniles does not necessarily guarantee survival and growth. Hosts 6–8 have additional males. Two of these are attached in front of the female, very similar to some traditional female-male pairings (*Renocila colini* Williams and Williams, for example). This suggests a method by which a traditional female-male arrangement could be developed from a duplex arrangement, but, in the case of *R. kohnoi*, some mechanism (for example: limited space available for attachment of adult isopods to the caudal peduncle, or more swimming stability of hosts with large isopods on both sides) seems to be maintaining the duplex arrangement. Hosts 9–10 (Table 3) have the unusual relationship of female and male-female transitional. This suggests lack of female control of the male over the distance of opposite sides of the host. If the male-female transitional also became a female on this host and if a functional male was small and mobile (as in Caribbean *Anilocra*), then a double female-micromale arrangement could develop.

Thus, the arrangement of individuals of *R. kohnoi* on a host displays the duplex arrangement as well as possible methods of changing to either a traditional or a double female arrangement. It is possible that the duplex arrangement is a precursor to the more frequently observed female-male re-

relationships, particularly when an isopod is parasitizing a new host.

Williams et al. (1983) reported the only known case of more than one species of *Renocila* (*R. bowmani* Williams and Williams and *R. colini*) occurring at the same geographic location (Isla Saona, Dominican Republic). We observed a specimen of *R. kohnoi* on a *Centropyge heraldi* among *Chromis ovatiformis* parasitized by *R. yamazatoi* south of Saba Saki in Amitori Bay.

The extremely limited geographic ranges, high levels of infection and strong host specificity suggested for the species of *Renocila* by Williams and Williams (1980) are not contradicted by these three new species from the Ryukyu Islands.

Key to *Renocila* Species

- 1. Dactyls of pereopods 1–3 with swelling on outer margin 2
- Dactyls of pereopods 1–3 without swelling 5
- 2. Antennae 1 shorter than antennae 2 *R. dubia* (Nierstrasz)
- Antennae 1 longer than antennae 2 3
- 3. Pleotelson longer than wide
..... *R. periophthalma* Stebbing
- Pleotelson wider than long 4
- 4. Dactyl of pereopod 4 with swelling on outer margin *R. kohnoi*, n. sp.
- Dactyl of pereopod 4 without swelling
..... *R. indica* Schioedte and Meinert
- 5. Antennae 1 and 2 subequal 6
- Antennae 1 longer than 2 9
- 6. Posteroventral angle of pereonite 7 produced laterally, not covering lateral margins of anterior pleonites in dorsal view 7
- Posteroventral angle of pereonite 7 not produced laterally, covering lateral margins of anterior pleonites in dorsal view 8
- 7. Posteroventral angle of pereonite 5 produced, antennae 2 extending

- beyond posterior border of head
.... *R. colini* Williams and Williams
- Posteroventral angle of pereonite 5 not produced, antennae 2 not extending to posterior border of head
.... *R. thresherorum* Williams and Williams
- 8. Brown in color, antennae 2 8-merous, antennae 1 slightly shorter than 2 *R. waldneri* Williams and Williams
- Black in color, antennae 2 7-merous, antennae 1 slightly longer than 2 *R. bowmani* Williams and Williams
- 9. Lobe of head between bases of antennae 1, exopod of uropod more than twice as long as endopod ... 10
- No lobe between bases of antennae 1, exopod of uropod only slightly longer than endopod 11
- 10. Posteroventral angle of pereonite 5 produced, dactyls of pereopods 2–6 lengthened . *R. yamazatoi*, n. sp.
- Posteroventral angle of pereonite 5 not produced, dactyls of pereopods subequal *R. heterozota* Bowman and Mariscal
- 11. Pereonites and pleonites with medial posterior projections, head immersed *R. bollandi*, n. sp.
- Pereonites and pleonites lack medial posterior projections, head not immersed *R. ovata* Miers

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Literature Cited

- Bowman, T. E., and R. N. Mariscal. 1968. *Renocila heterozota*, a new cymothoid isopod, with notes on its host, the anemone fish, *Amphiprion okallopis*, in the Seychelles.—*Crustaceana* 14:97–103.
- Brusca, R. C. 1981. A monograph on the Isopoda Cymothoidae (Crustacea) of the eastern Pacific.—*Zoological Journal of the Linnean Society* 73(2):117–199.
- Masuda, H., K. Amaoka, C. Araga, T. Uyeno, and T. Yoshino (Eds.). (1984) The fishes of the Japanese Archipelago. Tokai University Press, 437 pp.
- Trilles, J. P. 1964. À propos d'un fait particulier d'éthologie parasitaire chez les Isopodes Cymothoidae: La relation de taille entre parasites et poissons. Note préliminaire.—*Vie et Milieu* 15:365–369.
- Williams E. H., Jr., and L. B. Williams. 1980. Four new species of *Renocila* (Isopoda: Cymothoidae) the first reported from the new world.—*Proceedings of the Biological Society of Washington* 93:573–592.
- , and ———. 1982. *Mothocya bohlkeorum* new species (Isopoda: Cymothoidae) from West Indian cardinal-fishes (Apogonidae).—*Journal of Crustacean Biology* 2:570–577.
- , I. Clavijo, J. J. Kimmel, P. L. Colin, C. Diaz-Carela, A. T. Bardales, R. A. Armstrong, L. B. Williams, R. H. Boulon, and J. R. Garcia. 1983. A checklist of marine plants and animals of the south coast of the Dominican Republic.—*Caribbean Journal of Science* 19:39–53.
- Williams, L. B. 1984. Geographic distribution and early life history of *Anilocra* (Isopoda: Cymothoidae) parasites of Caribbean coral reef fishes. Auburn University, Ph.D. Dissertation, 312 pp.
- , and E. H. Williams, Jr. 1981. Nine new species of *Anilocra* (Crustacea: Isopoda: Cymothoidae) external parasites of West Indian coral reef fishes.—*Proceedings of the Biological Society of Washington* 94:1005–1047.

Foreign Visiting Researchers, Sesoko Marine Science Center, University of the Ryukyus, Motobu-cho, Okinawa 902-05 Japan. Permanent address: Department of Marine Sciences, University of Puerto Rico, Mayaguez, Puerto Rico 00708.